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cubic equation we find that at the critical point,  $\pi$ , the critical pressure  $= \frac{a}{27b^2}$ . Table II. gives the results of this calculation,

and it will be seen that the values for benzine and  $\text{NO}_2$  do not coincide with the values for  $\pi$ . As the values of  $a$  and  $b$  were originally calculated from  $\pi$ , it is evident that some misprint has crept into the tables, and there is little doubt but that if the correct values for  $a$  and  $b$  were substituted, they would fall into line and that in all cases the quantity  $a$ , in Van der Waals' equation, must be taken as equal to a quantity  $c$ , which is constant for all gases, multiplied by the atomic volume to the  $\frac{2}{3}$  power.

4. Electrical conductivity. As before mentioned linked atoms cannot conduct. If we examine the enclosed cube of the elements, we see that the non-conducting elements are found on sides  $E$  and  $W$  of the cube, and these are the elements whose atoms are linked or plexed. We can tell this in the following ways:—

N				E				S				W			
Metals of the Earths				Secondary Metalloids				Metals of the Arts				Primary Metalloids			
1	2	3	4	3	2	1		1	2	3	4	3	2		
H	Li	Be	B	C	N	O	F	Na	Mg	Al	Si	P	S	Cl	
40	K	Ca		Sc	Ti	V	Cr	Mn	Fe	Ni	Cu	Zn	Ga	As	Se
60	Rb	Sr	Y	Zr	Nb	Mo		Ru	Rh	Pd	Ag	Cd	In	Sb	Te
120	Cs	Ba	La	Ce											
160															
200															
240															

CUBE OF THE ELEMENTS.

1st, By their low specific heats. Those who are acquainted with chemical physics will recognize this fact and the necessary deduction. Briefly, if the kinetic energies of all molecules are the same at the same temperature, then if the sulphur molecule in solid sulphur is triatomic, or has its mass three times that of one atom; then since all the  $\frac{1}{2} m v^2$ 's are equal, solid sulphur will only have  $\frac{1}{3}$  the specific heat it would have if the molecule were monatomic (provided that no work is spent in disassociating the molecule.)

The standard atomic heat is 6.4. The following substances have low specific heats, and are all insulators or poor conductors: Sulphur, 5.4; phosphorus, 5.4; fluorine, 5; silicon, 3.8; carbon, 1.8.

2d, By their vapor densities. If a substance has a biatomic vapor it is not likely that it will be a monatomic solid. The following substances have two or more atoms to the molecule when in the state of vapor: sulphur, iodine, bromine, chlorine, selenium, tellurium, phosphorus, arsenic. And these are all insulators or poor conductors, while mercury, cadmium, zinc, and sodium have monatomic vapors and are good conductors.

As regards metals in the allotropic state. Allotropic is a word which has been used to cover a multitude of sins. Every time an erring element goes wrong and misbehaves itself by emphasizing some of its previous peculiarities, or develops some new ones, it is stigmatized as "allotropic." For instance, we see it stated that when iron amalgam is strongly heated the iron left behind is allotropic because it takes fire in the air. But such an action does not show that any new property has been developed, it merely emphasizes a fact already well known, i.e., that iron oxidizes when exposed to air. A fine cambric needle will catch fire when held in the flame of a Bunsen burner for a second, and

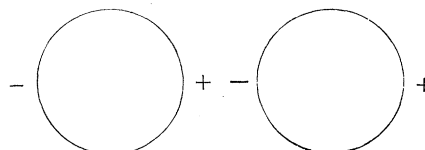
will continue to burn like a match after it is withdrawn. When the iron is in a finely divided state, the surface exposed is greater, and, the oxidation per unit of mass being much greater, the temperature of the iron is raised much more, thus favoring oxidation still more.

If, then, we are to use the word allotropic in this sense, we should logically speak of kindling-wood as an allotropic form of timber, for, as fire underwriters know, heavy timber is one of the most fireproof of substances. We might also speak of that form of conscience which large corporations are supposed to possess, as an allotropic conscience.

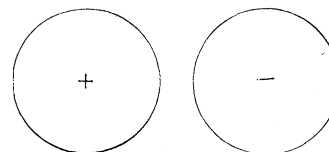
If, however, we do apply the word allotropic to such forms as Joule's iron, Cary-Lea's silver, etc., then we need another word to express the changes in the physical behavior of metals which are not due merely to the accenting of known properties but to the development of new properties, due to the joining of two or more atoms of a metal into one molecule. Polymerism might do, but it does not lend itself easily to use, and for myself I prefer to use the word plex, and to speak of diplexed iodine, triplexed sulphur, and of an element in a plexed form; though I have no doubt that if Clifford were still with us he would say that two-linked and three-linked are good enough for any honest Anglo-Saxon.

As regards the conductivity of "allotropic" elements, there is no reason to suppose that the conductivity of Joule's iron is different from that of ordinary iron. But when the elements are plexed, as we have seen above, the resistance will be much increased and the temperature sufficiently lowered, because heating increases disassociation nearly as fast as it lessens rigidity, or even in the case of those alloys or elements with negative temperature coefficients, faster.

[NOTE.—With regard to the previous paper, it may be noted that the explanation of the difference between cohesion and chemical combination, that in cohesion the atoms are charged similarly in every way except as regards position, thus —



while if any third substance short circuits the atoms they are left chemically combined, thus —



is also an explanation of a law which will probably be found true in the near future, i.e., no two substances can combine with each other without the presence of a third, thus making all chemical action the result of catalysis, plexed forms of the substances being capable of acting third substances. As regards the shortening of stretched rubber by heating, it is of course not to be supposed that the two parts of India rubber are literally contained one inside a sphere of the other, but that rubber rather resembles a tangled reel of silk embedded in jelly. If we consider any element of the jelly, and we see that it is bounded on all sides by threads of silk, and that these will act as the cell-wall of the previous paper, only "more so." The heating of rubber when stretched may be explained conversely by the compression of the jelly-substance by the cell-wall substance. R. A. F.]

#### THE GROOVE IN THE PETIOLE OF LEAVES.

BY AVEN NELSON, UNIVERSITY OF WYOMING, LARAMIE, WYOMING.

IN the spring of 1892, I had the pleasure of making some observations and brief studies, in conjunction with Mr. H. L. Jones, upon the origin and more particularly the function of the groove found in the petiole of many leaves, especially of *Endogens*.

Being at that time students in the Graduate Department of Harvard University, we laid under tribute the varied and extensive resources of the Harvard Botanic Gardens.

We first entered upon the histological study of the petiole and its groove, but soon discovered that that point of view alone would yield but meagre results: that we must depend largely upon actual experiment with plants showing this characteristic, and even more largely yet upon careful observation of the plants themselves in their habit of growth and mode of branching and the arrangement of leaves and roots on the particular plant under observation.

In order to get a starting-point it became necessary to make some guesses or suppositions as to the origin or purpose. Some of these suppositions came after a time to be so strengthened as to justify us in calling them theories, a few of which I will give with some of the facts supporting them.

In looking for the origin we do not find the groove developed as a characteristic structure earlier than in the Endogens. It is true that from the earliest differentiation of tissue into leaf we find in some instances the base of the leaf flattened and a strong suggestion of a groove as seen in some mosses, lycopods, ferns, and the bracts of the horsetails.

Finding the groove well developed in the Endogens almost without exception, and much less so in Exogens we are justified in concluding that in the Endogens there exists a necessity for such a leaf and petiole which is not found elsewhere. If, then, we can discover what this necessity is we shall, at the same time, have arrived at the origin of the peculiarity, for a plant by selection develops those structures best suited to its growth and perpetuation.

Without troubling myself at present about the reason for the difference in the habit of growth of Exogens and Endogens, but accepting these as we find them, keeping in mind always that a change in the habit of growth of one part of a plant, due to a change in surroundings, may necessitate a change in other parts as well, we will notice the habit of growth of Endogens.

Here we find plants with an unbranched stem, sometimes quite long, but usually short and often reduced to a minimum. The leaves are, as compared with the leaves of Exogens, few in number but quite large, often extraordinarily so. In these facts we can see some reasons for the grooved petiole. Like all leaves they must be attached in some way, and nature will find the most convenient way if at the same time her other purposes can be subserved. Now, where space is at a premium as in very short stemmed species or as in palms where the leaves are crowded into a terminal bud, what better arrangement than grooved flattened petioles overlapping each other can be suggested?

But it is not only the most convenient way, it is also the strongest way in which these could be attached. In a large number of plants we find the base of the petioles so closely overlapping that all are bound into so compact a mass that it would be almost impossible to pull out one without destroying the whole whorl or, I may say, the whole plant. This sheathing and overlapping of the petioles is coincident with the groove, or, I had better say, the groove is largely coincident with a sheathing base of the leaf.

So then I would say that convenience of attachment for the leaf and great strength for the plant as a whole are the first gains to be noted. As examples I may cite most palms and other Endogens with a very short stem and large leaves, or, to specify a few, *Latania Borbonica*, *Pandanus utilis*, *Homalomena caerulea*, several of the *Bilbergias*, *Crinum asiaticum*, *Pitcairnia hystris*, *Bromelia pinguin*, etc.

Before leaving this subject of strength the gain to the individual leaves by a sheathing base or grooved petiole needs to be noted.

We are all aware that from a given amount of material a stronger structure is produced if arranged in the form of a hollow cylinder than if in a solid column. Nature makes use of the hollow cylinder in grass stalks where strength and lightness is desirable, why not then, so far as possible, use the same economy in supporting those immense endogenous leaves, many of which are subjected to tremendous strain because of the long petioles necessary to carry them out into the sunlight?

As a matter of fact we do find them in all degrees from a completely sheathing base to half-cylinders, even the latter of which is greatly stronger than the same amount of material in a solid column.

Then, again, that mode of attaching the leaf gives greater strength because one side of the petiole braces the other. That could best be shown practically, yet one can easily conceive that where, for instance, the extreme margins of the petiole are attached to the stem 180° apart, each margin furnished with its fibro-vascular bundles continuous into the stem, these marginal fibro-vascular bundles act as guy ropes upon the long petiole leaf as it is swayed by the breeze.

We may further note the convenience of attachment with respect to the fibro-vascular bundles themselves. These being continuous from the leaf into the stem and the leaf attaching in a semi circle at a uniform height on the stem there is no necessity for a convergence of these bundles at a given point. But a greater number of bundles can pass naturally and directly into that part of the stem down which they continue. As examples illustrating this I would call your attention to corn and the grasses generally.

The groove having been formed in the base of the petiole it naturally persists throughout its whole length and even in the midrib of the leaf. Development in this manner, rather than a change from a grooved to a cylindrical form, represents development along the line of least resistance.

It has been suggested that the groove represents the persistence of a former condition or type and that at present the groove is merely incidental and no longer functional. This does not seem probable, however, for as noted before we find little trace in forms earlier than Endogens and again passing away in Exogens. There is nothing to show that the groove is not to-day at its highest state of development and differentiation.

It is developed, as I believe, because of the unbranched and often much shortened stem with the accompanying large leaves found in the Endogens. In Exogens, where found, it seems to perform the same functions already pointed out for Endogens, or oftener it is here merely a persistence of a former habit of growth.

In the preceding statements I believe I have pointed out the ancestral significance of the groove in the petiole. It now remains to see whether, because of a change in surroundings, this groove has secondarily taken on any new functions.

It has been suggested: 1. That the groove and axillary pockets thus formed may be regions where the absorption of water takes place. 2. That the groove guides the water to the young nascent buds in the axils and that these may absorb. 3. That the groove directs the water towards the main axis of the plant, and that in such plants the root-hair area will be found near the main axis.

If the above functions are found now to exist in some plants, I think they have been acquired secondarily and comparatively recently. The groove I consider coincident to and co-existent with the endogenous type of vegetation. Furthermore, at the time when the endogenous type was the prevailing vegetation, there was no necessity for the assumption by the petioles of the above-mentioned functions. There are reasons for believing that the regions where this type of vegetation took its rise were exceedingly well watered, and the ground, being wholly shaded by the denseness of the foliage, was at all points of nearly uniform moisture, usually nearly saturated. In fact, this is still the condition where this type of vegetation is most luxuriant.

Careful microscopic examination of the tissues and their arrangement in the groove and in the axillary pocket formed by the petiole showed essentially the same structure as on other parts of the petiole—cutinized always, sometimes as heavily as outside, usually without stomata in the pocket and few in the groove. A large number were examined, and it seems justifiable to conclude that, ordinarily, the groove is not an absorbing region.

There are, however, a few anomalous conditions and structures, the use of which is difficult to comprehend. In the *Bilbergias* we find the base of the petiole bearing a large number of radiately branched trichomes situated in small depressions in the epidermis. It should be said that these petioles are so arranged on the stem as

to form pockets capable of holding water, and that if these pockets are filled with water the trichomes, both outside and inside, will be submerged.

Also in Tulips the tightly-folded sheathing base is covered on the inside with a large number of thin-walled hair-like trichomes. In fact, the resemblance to root-hairs was quite close. The leaf was adapted for guiding any water that might fall upon it directly to this region of trichomes. Here it seems possible, as also in the Bilbergias, that the plants may have developed, because of a change in the conditions under which they grow, these additional absorbing structures.

A series of experiments, however, failed to give conclusive proof of this function. Several innocuous liquid stains were placed and retained for hours, and even days, in these axillary pockets, after which sections were made of various parts of the stem. In a few instances the tissues were unmistakably stained. Oftener, however, no trace of absorbed stain could be found.

*Yucca*, a plant of arid regions, possibly also absorbs water through the base of the petiole, since we find on that part of the petiole which is wholly buried among the petioles of the surrounding leaves a large number of stomata.

These stomata may absorb water trickling into this region without at other times subjecting the plant to dessication, as they would if found on exposed parts of the leaf.

Now as to the root-hair area. Do we find in those plants whose leaves direct the water toward the main axis that the area of root-hairs is near the axis, and, on the other hand, that where the water is drained outward it will fall near the region of greatest root activity?

I believe we do in a very large majority of cases. There are plenty of exceptions, but I believe they are exceptions and not the rule. As examples note all the grasses with fibrous roots, and many other Endogens growing from corms, bulbs, and rhizomes, from which grow out great masses of short, fibrous roots. On the other hand, note the forest trees, generally shedding the water outward and carrying the water toward if not to the root-hair area. But now I am not going to assert that the groove has been developed in order to direct the water inward, nor that the branches droop in order to carry it outward. On the contrary, if the root-hair areas are found as I have asserted, it is because these are the areas of greatest moisture, not that these have been made the areas of greatest moisture because the root-hairs existed there. The plant in sending out its roots seeks for moisture, and where that moisture and food is found in its most available form, it will develop root-hairs.

It does not seem then that the position of the root-hair area had any thing to do with the original formation of a grooved petiole, and I will again state that I believe the grooved petiole co-existent with and a necessity to the endogeneous type of vegetation.

#### THE CLEANSING FUNCTION OF HAIRS.

BY HENRY SEWELL, PH.D., M.D., DENVER, COLO.

THE student of animal morphology is never so happy as in the discovery of a rudimentary organ or some structure which seems a worthless burden to its possessor; for, with an unacknowledged belief in a sort of teleology, he hopes by finding the origin of the useless appendage that the tangle of phylogeny may be loosened.

The student of animal physiology, on the other hand, is never more complacent than when to an apparently useless structure or unmeaning arrangement he can attribute some function by virtue of which the body is made a more efficient machine.

An interesting example of the subservience of form to function, which the writer has never seen mentioned, is found in the arrangement of the epidermic scales which form the outermost layer of animal hairs. The buried edges of the scales point towards the root of the hair, while the free edges project obliquely in the direction of the hair end, as the shingles on a roof point to the eaves. When a hair is drawn between the thumb and forefinger, which are gently pressed upon it, it will be found that the hair glides far more easily when pulled from root to tip

than in the opposite direction. When the hair is simply rolled between the thumb and finger it will gradually move parallel to its length in the direction of the hair root. These results depend altogether on the way in which the hair-scales project from the hair axis. It is at once obvious that foreign particles clinging to the hair *in situ* would find easy the passage outward towards the tip and away from the surface of the body, but exceedingly difficult the progress in the opposite direction. Every movement of the hair, especially frictional disturbance, must set up a current of foreign particles towards the hair tip. The housewife has long known by experience how much more readily a vigorous shaking cleanses a woolen garment than one made of cotton.

The sebaceous glands opening at the mouth of the hair follicle, probably play an important part in surface cleansing; for their oily secretion sticks together the particles of shed epithelium, associated with all manner of filth, in such a manner that the "hair-rakes" can, no doubt, more easily remove them.

Ludwig long ago showed that, in the same way, the mucus secreted by the surface epithelium of the stomach and intestines agglutinates the detritus which covers the mucous membrane after digestion, and so makes possible its removal by the peristaltic action. The housewife, again, uses the same principle when she sprinkles a very dusty floor before sweeping, and finds the filth to roll before her broom.

One more reference to physiological body-cleaning: It has been found that the growth of epidermic epithelium proceeds in such a way, at least in certain situations, as to remove the worn-out cells *en masse*. Thus, on the external surface of the eardrum, the direction of growth is such that the epithelial scales progress, pushed from below, steadily from the centre of the membrane and then along the meatus to the exterior. Foreign particles lying on the epidermis are of course carried with it.

#### NOTES AND NEWS.

THE first annual meeting of the Ohio Academy of Science was held at Columbus on Dec. 29-30, 1892. After some formal business, such as the appointment of committees, had been attended to, the reading of papers began. The following, among others, were read during the session: The Advantages of *Arzama obliquata* for Laboratory Instruction, D. S. Kellicott; The Inhabitants of a Species of Gall on Wheat Plants, F. M. Webster; Some Anticlines found in the Shales of Northeastern Ohio, Geo. H. Colton; Lantern Slides without a Negative, W. G. Tight; A Few Rare Ohio Plants, Aug. D. Selby; New Plants for the Flora of Ohio, W. C. Werner; Notes on the Distribution of Some Rare Plants in Ohio, W. C. Werner; Lichens of Ohio, E. E. Bogue; Leaf Variation: Its Extent and Significance, Mrs. W. A. Kellerman; Some Insect Migrants in Ohio, F. M. Webster; The Uredineæ of Ohio, Freda Detmers; Ohio Erysipheæ, Aug. D. Selby; The Development of the Berea Stone Industry, J. H. Smith; Snow-Rollers, W. S. Ford; Note on a Nest of White Ants, O. L. Sadler and Mrs. O. L. Sadler; The Histology of the Stem of *Pontederia cordata* L., E. M. Wilcox; Pulmonary Fistula in a Frog, J. B. Wright; Note on a Skull Pierced by a Stone Spear-Head, E. W. Claypole. In the evening the president, Dr. E. W. Claypole, delivered the annual address, taking for his subject "Devonian Ohio, or a Passage in the Making of the State." Premising that such an address should not be one intelligible only to geologists, as the majority were not specially devoted to that science, he outlined the geological history and growth of the region from the commencement of the deposition of the Corniferous Limestone to the base of the Berea Grit. The first part of the era was a time of profound peace, when a coral sea overlay all the State. This was followed by a time of depression, when the vast beds of shale were laid down. The fishes of that era, as preserved in these shales, came in for full consideration, and their immense bony plates were illustrated by numerous drawings. The leading genera were *Titanichthys*, *Dinichthys*, and *Gorgonichthys*. Mr. W. K. Moorehead was appointed a committee on archæology, especially with a view to the investigation of the antiquities of Ohio, and Professor G. F. Wright was made a committee on boulders.